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Non-homogeneous structure of neutral winds in the lower thermosphere during the MAC/EPSILON campaign

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Abstract—The paper presents the results of an investigation of the height variations of dynamic processes in the 80–110 km height region, carried out in Kazan, U.S.S.R. (56°N, 49°E) by the radiometeor method during the MAC/EPSILON campaign. Experimental results show that the largest values of vertical wind gradients, as well as zonal and meridional temperature gradients can be found at heights of ~83 km. At heights of $80 \leqslant h \leqslant 100$ km, we can observe energy absorption of IGW and tides which are the major sources of turbulent energy in the above-mentioned height interval. Using the effects of IGW energy absorption, values of the turbulent eddy diffusion coefficient K_t ranging from 1600 to 4400 m^2/s were calculated for October 1987. The energy dissipation rate ε was estimated to be from 0.1 to 0.4 W/kg.

1. INTRODUCTION

The MAC/EPSILON campaign investigated the problem of turbulence in the upper atmosphere in the late autumn. This paper presents experimental data for waves with periods from 60 min to 7 days, as well as the characteristics of the prevailing circulation in October–November 1987. The results considered in the paper were obtained by radiometeor measurements made at the Kazan radar station (56°N, 49°E), which is equipped with height-measuring instrumentation (SIDOROV *et al.*, 1981).

2. METHOD OF ANALYSIS

In order to determine the thermodynamic condition of the lower thermosphere, height variations of the zonal and meridional components of the prevailing wind were analysed with a height resolution of 3 km. The values of horizontal temperature gradients were computed assuming thermal wind in geostrophic balance. The change of wind with height (the height difference being given) is determined by the value and direction of the horizontal gradient of the mean temperature:

$$u_T = u_g(h_{i+1}) - u_g(h_i) = -\frac{g\Delta h}{lT_m}\frac{\partial T_m}{\partial y} \tag{1}$$

$$v_T = v_g(h_{i+1}) - v_g(h_i) = \frac{g\Delta h}{lT_m}\frac{\partial T_m}{\partial x} \tag{2}$$

where u_t and v_t are the zonal and meridional thermal wind components, g the acceleration due to gravity, T_m is the mean temperature in the layer with thickness Δh. Values $u_g(h_i)$, and $v_g(h_i)$ are the zonal and meridional components of the prevailing wind in geostrophic balance at the height level h_i. The zonal and meridional gradients of mean temperature in the layer at the height h will be correspondingly:

$$\frac{\partial T_m(h)}{\partial x} = \frac{2\omega \sin\varphi T_m}{g}\frac{\partial v(h)}{\partial h} \tag{3}$$

$$\frac{\partial T_m(h)}{\partial y} = \frac{2\omega \sin\varphi T_m}{g}\frac{\partial u(h)}{\partial h} \tag{4}$$

where $u \approx u_g$, $v \approx v_g$, φ is latitude, and ω is the angular velocity of the Earth's rotation.

Equations (3) and (4) are used to calculate the relative horizontal temperature gradients: $\Gamma_x = (\partial T_m/\partial x)/T_m$ and $\Gamma_y = (\partial T_m/\partial y)/T_m$. We have also computed the value of u and the direction ψ of the prevailing wind vector. Figure 1 presents the height variations of u, ψ, Γ_x and Γ_y for October 1987. The largest value of u, and the largest negative values of Γ_x and Γ_y can be found at about 83 km. The direction of the prevailing wind changed strongly with height; the wind vector turned 360° in the height interval from 80 and up to 101 km. In November 1987 the direction of the prevailing wind changed by 30° only in the height interval from 80 to 110 km.

Figure 1 shows that the maximum values of the prevailing wind and the vertical wind shear, as well as the largest negative zonal and meridional temperature gradients, can be observed at a height of about 83 km. Γ_x and Γ_y show fluctuations with vertical scales of ~6 km superimposed on a general, slower change with height. The mean meridional gradient Γ_y changed its sign at the height of about 89 km.